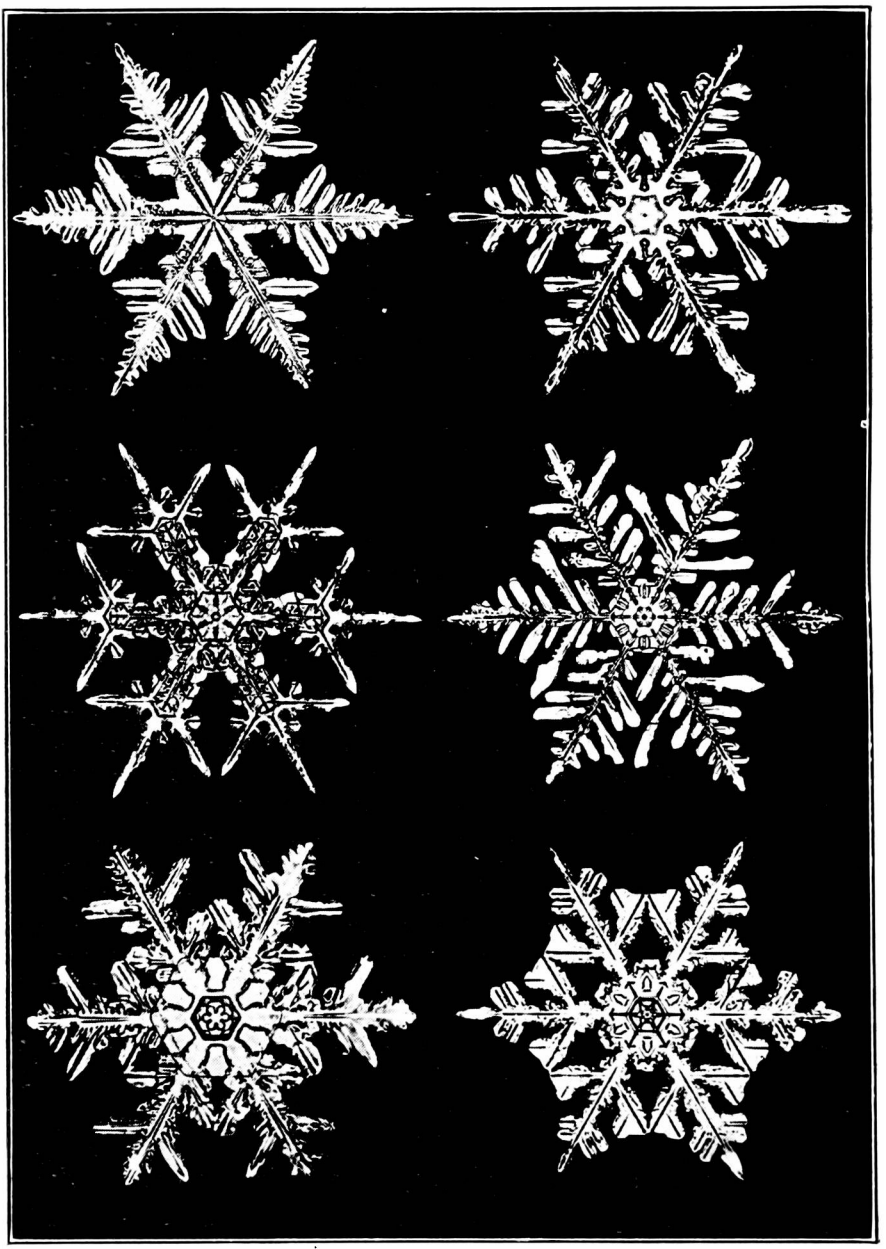

SNOW CRYSTALS

(reproduced from "Snow Crystals" by W. A. Bentley and W. J. Humphreys, p. 181).

M.O. 347.

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The Fascination of Snow Crystals*

Every meteorologist who has given any attention to the forms of snow crystals is familiar with the beautiful photographs made by Mr. W. A. Bentley. Selections from Mr. Bentley's store have been reproduced from time to time. We have now to thank an anonymous admirer of the photographs for making possible the publication of a magnificent album containing more than two thousand illustrations. At the request of the American Meteorological Society, Professor Humphreys has collaborated with Mr. Bentley by assisting in the selection and classification of the pictures and by writing a lively descriptive introduction to the collection. There is only one fault to find with this introduction. We should have liked to see the pictures through Mr. Bentley's eyes and to learn a little more of his personality. What is he by trade or profession? What made him take up his fascinating hobby fifty years ago? Has he distinguished himself in other work with microscope and camera? Perhaps such questions will be answered in a second edition of the album, for the present one is published with the optimistic words " First Edition " on the title page.

As will be seen from the illustrations which we reproduce the photographs appear on a black background. This background is

*Snow Crystals. By W. A. Bentley and W. J. Humphreys. Size 12 × 9½ in. pp. ix. + 227, *Illus.* New York and London. McGraw-Hill Publishing Co. Ltd. 1931.

(97989) 107/27 1,075 4/32 M. & S. *Gp.303*

secured in an ingenious way. When the photograph is taken the crystal is flat on a microscope slide. The background of clear glass would appear white on a print. Mr. Bentley makes a duplicate negative and carefully cuts away the film round the picture. In the final print the background is black.

In England we may well be jealous of the opportunities enjoyed by Mr. Bentley for his work. His home at Jericho, Vermont, at no great height above sea-level, is about sixty miles from Montreal, so the climate is like that of eastern Canada. One gathers that isolated crystals are the usual form of snow. The photographer has had no temptation to portray the fluffy snow-flakes with which we are familiar.

In looking at the pictures it is difficult to realise that the delicate lines which seem to be etched on the crystals are not really black. We are told that the crystals are often ridged. In taking the photographs the light of the sky is passed through a stop of small aperture before reaching the crystal. Light which falls on an oblique surface is refracted and never reaches the microscope lens. That is why ridges and furrows and the slopes of plateaus would appear black in the pictures. One wonders to what extent such surface irregularities are really responsible for the patterns in the pictures. Some of the markings are certainly internal. They indicate where growths from opposite directions have consolidated.

How far can we go in explaining on physical principles these wonderful designs?

We can make a start by utilising the results of X-ray analysis and elementary chemistry. The work with X-rays tells us that an ice crystal is built up on a simple plan. Think of a flat criss-cross pattern made of three sets of equidistant parallel lines. Of the equilateral triangles formed by these lines let half be shaded. Now suppose that a little pyramid (a regular tetrahedron) stands on each shaded triangle. The vertices of the pyramids mark the corners of a pattern like the first. The triangles to be shaded in the new pattern are those which come over the corners of the first one. More pyramids stand on the new shaded triangles. The process can be repeated indefinitely. Now suppose that there is an oxygen atom at each of the corners and also an oxygen atom at the centre of each tetrahedron. This is the distribution of oxygen atoms as revealed by X-rays. Chemistry tells us that there must be twice as many hydrogen atoms as oxygen ones and we satisfy this condition by tucking the hydrogen atoms between the oxygen atoms and their nearest neighbours, four hydrogen atoms in each tetrahedron. The scale of this structure is such that the minimum distance between the centres of oxygen atoms is 2·75 Ångström units and the sides of the little equilateral triangles with which our description commenced are 4·5 Ångström units. Since there are 10^7 Ångström units in a millimetre, a

figure can readily be drawn with a magnification of 20 million.

The essential feature of the ground plan of the crystal structure is the equilateral triangle, but there are clearly six directions in which the plan can be extended without sacrifice of symmetry so it is not surprising that the hexagon is the typical form of ice. Crystals of triangular form are however well represented in the Bentley collection.

It is by no means certain that there is only one fundamental arrangement of the atoms of oxygen and hydrogen in ice. The fact that, whilst some crystals are flat plates, others are long prisms, suggests that under different circumstances of growth the elementary parts are arranged in different ways. The structure which we have described could be varied by supposing that the second set of triangles was located in such a way that the shaded triangles were not centred over the corners of the first set. The two types of ice crystal would be related in much the same way as the two forms of crystalline carbon, graphite and diamond. It is strange that no X-ray analysis of flat crystals, such as Mr. Bentley photographs, has been brought to the notice of meteorologists.

The condition which determines whether these regular crystalline forms of ice shall occur in snow crystals has been laid down recently by G. Stüve of Frankfurt. He considers that when moisture condenses on a nucleus of salt at a temperature a little below 32°F. the first condensation is in the form of liquid brine. As condensation proceeds the liquid droplets grow, collide and eventually freeze. The frozen droplets are irregular; they may grow into columnar forms as they fall, but they never become symmetrical snow crystals. On the other hand, says Stüve, if the temperature is below the freezing point of concentrated brine, about 0°F., then no liquid water will be deposited on the original salt of the nucleus; the deposit will take the form of ice and conditions will be favourable for symmetrical growth. So far as the significance of the limit 0°F. is concerned Stüve's theory might be tested by observation. What temperature is to be found in Ottawa when regular snow crystals are formed from the steam in the railway station?

Now we are faced with the question how a crystal grows. Looking at one of Bentley's pictures we are forced to admit that the symmetrical closed curves and polygons represent the boundary of the crystal at certain stages of growth. If Mr. Bentley had cut away his negatives along some of these curves he could have given us an instructive series of pictures representing the life-history of a single crystal. There are, however, but few cases in which the record is clear, in which one could give precise instructions as to where the film was to be removed.

Generally one has the impression that the process of growth must have been intermittent, that the artist paused when he had

made a neat outline before deciding how to extend the pattern. There are moreover some cases in which it looks as if the plate had been completed before the design was sketched on the surface.

One can make an attempt at a physical explanation of symmetry in crystal growth. Inside the crystal there is a nice balance of electric force. We believe it is the electrical attraction between the negatively charged oxygen atoms and positively charged hydrogen atoms that holds them together. Round the edges and on the faces of the crystal there is a complicated electric field and molecules of water vapour coming into the field are liable to capture. As long as the crystal is symmetrical the electric field is symmetrical and the chance of capturing molecules is symmetrically distributed. Therefore the growth will continue to be symmetrical. The rate of growth will depend on temperature and humidity, and as each crystal, drifting through strata of varying water content, has a different history, each crystal develops its own special pattern.

That story is very nearly plausible, but I must confess that when I look back at the photographs I am not satisfied. I cannot help feeling that there is a controlling force of which we know nothing. It seems as if there had been a master mind controlling a team of Maxwell demons and ordering them to place so many molecules simultaneously at corresponding points on all the edges of the crystal.

This example of the orderly development of crystal structure will surely have important lessons for the philosopher of the future; so we may hope that the publication of the Bentley album will, in due course, lead to fuller knowledge of the mysteries of space and time.

Postscript.—Readers of the *Meteorological Magazine* will be aware that since the foregoing article was written the death of Mr. Bentley on December 23rd, 1931, has been announced. He had lived to see the best evidence of the appreciation with which the work of his leisure hours was regarded by his scientific friends.

F. J. W. WHIPPLE.

Winds in London during the early 19th Century

By C. E. P. BROOKS, D.Sc.

During the course of a recent discussion at the Meteorological Office, Mr. D. Brunt called my attention to a period of abnormally high barometric pressure in Paris, at the beginning of the 19th century. I had previously noticed that the winds in London at that time presented some abnormal features, and it seemed that a detailed study of the variations of wind direction during that period might have some interest. There is abundant material, though unfortunately, as will be seen, some of it is of

poor quality. A search revealed the following series of observations :—

1. A weather diary in the library of the Royal Observatory, Greenwich, covering the period 1771-1821, kindly lent by the Royal Astronomer. Until 1774 this was kept at or near Kennington, then until June, 1782, at Muswell Hill, and for the rest of the period at Syon House, Isleworth.

2. A weather diary kept at the rooms of the Royal Society, Somerset House, from 1774 to 1780 and 1786 to 1825. A manuscript copy of this is in the library of the Royal Meteorological Society.

3. A weather diary kept by the Rev. W. Cowe, M.A., at Sunbury Vicarage, Middlesex, from 1795 until 1839. This was reproduced photographically and published in a limited edition in 1889.

4. A weather diary at Somers Town from 1811 until 1842. This is in the library of the Royal Meteorological Society.

5. A series of observations by Luke Howard at Plaistow, Stratford and Tottenham, published in the second edition of the "Meteorology of London."

6. A series of observations at Chiswick from 1826 to 1840. Summaries of these are given in the "Report upon the meteorological observations made in the Garden of the Horticultural Society," published annually in the "Horticultural Transactions."

7. The record of the anemometer at Greenwich Observatory, which commences in 1841.

The first four of these series had not previously been summarised, and the first step was to prepare monthly tables of wind frequency for each year; this was done with the assistance of Miss T. M. Hunt. These tables are being typed and copies will be filed for reference, but the figures in this form are far too bulky to handle. They were accordingly reduced to "direction frequency vectors," each observation being given unit value irrespective of velocity. This process of course does not give the resultant air movement, but it gives a fair representation of what may be termed the "wind climate." Except at low speeds, the direction of the wind is a good indication of its origin and characteristics. Also, it was this or nothing, as no satisfactory indications of velocity are available before 1841. The components of the vectors from north and east were calculated separately, for each year and for each winter (December to February) and summer (June to August).

At this stage the components for the year for all stations were plotted on squared paper. The results were interesting, but also rather disappointing. For the period 1811 to 1821, which is covered by all the records except Chiswick and Greenwich, the curves of east component form a narrow band, indicating that

all the records are in close agreement. The curves of north component are more widely scattered, and Luke Howard's observations especially showed a consistently large positive value. As this series is also very broken as regards locality, it was rejected. The remaining series show little trace of systematic differences, and their average probably eliminates most of the individual errors. After 1827, however, the Somers Town record shows a rapidly increasing frequency of north-westerly winds, probably because the vane was not balanced. If the broad tail of the vane was heavier than the head, as it often is, and the spindle became bent over towards the south-east, there would be a bias in favour of an apparent north-west wind, and this bias would tend to increase with time. Hence the Somers Town record was rejected after 1827. The earlier years were more difficult. Before 1795 we have only Syon House and the Royal Society. From 1794 onwards these two records are in good agreement, but before that date they diverge hopelessly, both in general trend and in minor details. The change from Muswell Hill to Syon House coincides with a marked apparent change in wind direction. The Royal Society record also shows some improbable features about 1790, due I think to friction of the anemometer. Hence it was judged best to reject the early years of both series, and to commence the study with the winter of 1793-4. After some experimenting with small corrections, the wisest decision appeared to be to take the actual means of the acceptable data as the wind components for London in each year, and these means were again plotted.

The results are shown in fig. 1, the three pairs of curves representing the year, winter and summer. The data for winter are entered to the year in which January and February fall, but include also December of the preceding year. The vertical scale represents the " direction frequency vector " on the scale of one unit per day, north and east being positive, south and west negative. The full line shows the component from north, the broken line that from east. Thus the resultant direction can be read off as follows :—

north curve +, east curve +, wind north-east
north curve +, east curve −, wind north-west
north curve −, east curve +, wind south-east
north curve −, east curve −, wind south-west.

The two horizontal lines traversing the diagram for the year, below the zero line, give the average components at Greenwich during the 60-year period 1860 to 1919, which happened to be readily available. The full line represents the north component, the broken line the east component. The isolated full line, which comes between the components for the year and those for winter, represents the resultant direction frequency vector calculated from these components. It was inserted to make the meaning

of the components clearer to the eye. The broken horizontal line in this diagram shows the resultant at Greenwich from 1860 to 1919.

Considering first the curves of the annual components, it is seen that while the full curve oscillates about a nearly horizontal axis, the axis of the broken curve has a decided downward trend from left to right which continues throughout the first quarter of the 19th century. In other words, while the excess of

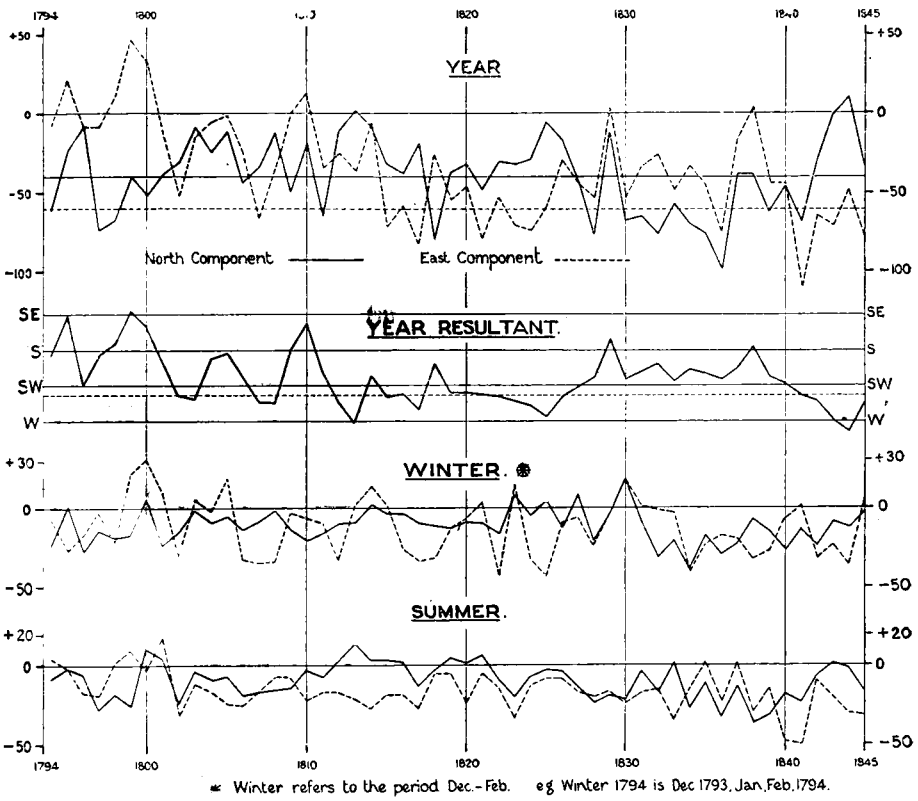

FIG. 1.

southerly over northerly winds showed little variation during the period, there was a distinct tendency for easterly winds to be more frequent and westerly winds less frequent in the earlier years than in the later years.

The curve of resultant directions shows a remarkable swing from an average direction east of south between 1794 and 1800 to west-south-west after about 1810. This runs parallel with the variations of annual rainfall in England, which according to the figures compiled by J. Glasspoole* show a marked minimum from 1795 to 1805, and maximum from 1816 onwards, the succeeding minimum not occurring until the 1850's. In Scotland

*_Meteorological Magazine_, 63, 1928, pp. 4-5.

the rainfall was deficient during the years before 1810, both at Rothesay in the west and Edinburgh in the east, and increased markedly during the following years, the increase amounting to about 6 per cent. The long series of wind directions at Edinburgh, collected by R. C. Mossman* also show a marked change about 1810, but instead of being from south towards west, as it was in London, the change was in the reverse direction, from west towards south, and much smaller in amount. The figures are shown in the following table:—

TABLE I.—ANNUAL WIND FREQUENCY VECTORS.

YEAR	LONDON				EDINBURGH			
	Components		Resultant		Components		Resultant	
	N.	E.	Direction	Amt.	N.	E.	Direction	Amt.
1794-1810	—35	— 7	191°	36	0	—111	270°	111
1811-1827	—31	—51	238	60	—41	— 79	242	89
1828-1840	—61	—36	210	71	—24	— 74	252	78

Directions are measured in degrees from north through east, 180° being south and 270° west. Components and amounts are in days per year.

When we turn to the pressure data, we find an equally remarkable change, also about 1810. Taking as a basis the same three intervals 1794-1810, 1811-1827, 1828-1840, we find that the mean annual pressures reduced to mean sea level were:—

Paris ... ... 1017·6mb., 1016·1mb., 1016·3mb.
Edinburgh ... 1011·7mb., 1012·1mb., 1012·3mb.

Between the first and second periods pressure fell no less than 1·5mb. at Paris, but rose 0·4mb. at Edinburgh.

It remains only to fit these curious facts together, and this is not difficult. During the first period, 1794 to 1810, there must have been a definite tendency towards the frequent establishment of anticyclonic conditions over France, giving the high pressure at Paris. This anticyclonic tendency extended northwards over southern England, but did not extend far to the west, so that near London the average isobars ran from south-south-west to north-north-east, giving almost southerly winds. Owing to the anticyclonic conditions, however, the winds were very variable, the magnitude of the resultant vector being only 36, or 10 per cent. Also the rainfall over England was small, another indication of frequent anticyclonic conditions. In south-eastern Scotland, on the other hand, the isobars ran from west to east and were crowded closely together, giving strong and steady westerly winds. The magnitude of the vector at Edinburgh is as much

*The meteorology of Edinburgh. *Edinburgh, Trans. R. Soc.*, 38, 1896. Pt. III. No. 20, pp. 681-755; 39, 1897, Pt. I, No. 6, pp. 63-208.

as 111 days, or 30 per cent. These conditions are shown by the full lines and arrows in fig. 2. We may attribute the small rainfall at Rothesay to the westward divergence of the isobars, and at Edinburgh to a rain-shadow effect in the steady westerly winds.

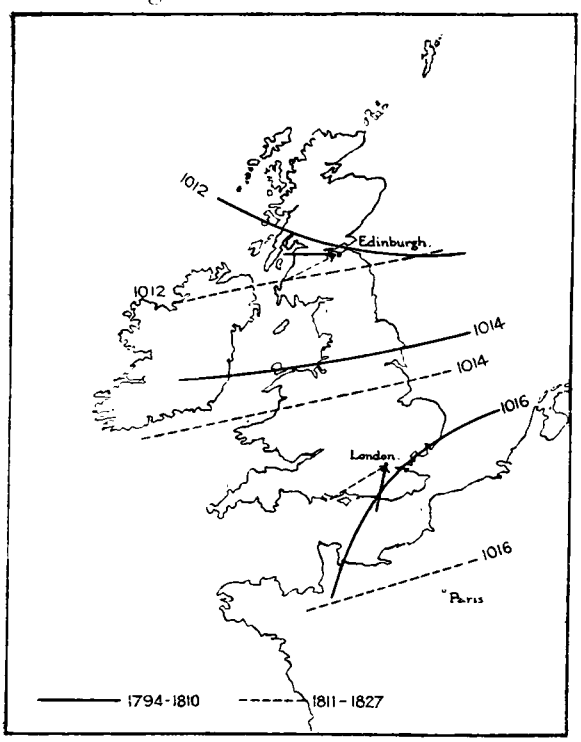

FIG. 2.

The broken lines and arrows in fig. 2 show conditions during the period 1811 to 1827. The wind arrows at London and Edinburgh, instead of being inclined almost at right angles, run practically parallel from between south-west and west-south-west, suggesting that the average pressure distribution over the British Isles now consisted of a series of parallel isobars running from west-south-west to east-north-east, while the relatively low pressure over Paris, the relatively heavy rainfall over England and Scotland, and perhaps also the decreased steadiness of the wind at Edinburgh, point to depressions crossing England with increased frequency. The whole is a surprising example of the amount of information which can sometimes be drawn from the scanty data of the early days of meteorology.

The pressure data indicate that similar conditions to those of 1794-1810 extended back towards the middle of the 18th century. Although the early wind records at London had to be rejected, it should be remarked that they point strongly to the prevalence of southerly winds from 1783 to 1793, as well as from 1794 onwards, and this result can probably be accepted qualitatively though not quantitatively.

The curves for winter and summer are of interest for the student of severe winters and hot summers. Without going into detail, it may be mentioned that of the years which gave a resultant wind from north-east in winter, namely 1800, 1814, 1823 and 1830, the first was not especially cold, but the winter of 1813-4 was the most severe of the century, and was the

occasion of a notable " frost fair." The winters of 1822-3 and 1829-30 were also very cold in London. The mean temperatures of these four seasons were respectively 37·3°F., 31·9°F., 34·9°F. and 33·3°F., compared with a " normal " at Greenwich of 39·5°F. It may perhaps be surmised that during the winter of 1799-1800, which had an almost normal temperature in spite of the frequent north-east winds in London, the conditions resembled those during February, 1932,* with an isolated anticyclone to the north-west, so that the source of the air which reached London lay over the Atlantic to the northward. During the winter of 1813-4, on the other hand, it may be surmised that the high pressure to the north of England formed part of a long anticyclonic belt extending eastwards over northern Europe, as in February, 1929, so that the source of the air lay in northern Russia or Siberia.

Royal Meteorological Society

The monthly meeting of this Society was held on Wednesday evening, March 16th, at 49, Cromwell Road, Prof. S. Chapman, F.R.S., President, in the Chair. As is customary in March the meeting took the form of a lecture (The Symons Memorial Lecture), which was delivered on this occasion by Dr. B. A. Keen, F.Inst.P., Assistant Director, Rothamsted Experimental Station, his subject being

Soil Physics in Relation to Meteorology.

Although the physical properties of the soil are of vital importance in agriculture it is only in the past 15 years that they have been studied in detail by competent physicists. The Soil Physics Department at Rothamsted, which is in Dr. Keen's charge, is now recognised as the leading centre for this work. The lecturer introduced his subject with a description of the different soil types found in different climatic zones. In discussing soil temperatures it was pointed out that the porous and moist nature of soil produced special effects. In particular the downward percolation of water appreciably reduced the loss of heat from the soil. A full account was given of recent investigations at Rothamsted on the movement and distribution of water in the soil. It was shown that such movements are much less both in amount and extent than was previously supposed. Water which has reached a depth of about 6 feet in the average soil is not drawn back to the surface again by evaporation. Many of the farmers' and gardeners' cultivation operations were supposed to conserve this sub-soil water for use by plants, but the explanation has now to be sought for in other directions. The lecture concluded with a review of the development of cultivation implements from the rudimentary form of a pointed stick, which merely

Meteorological Magazine, 67. 1932, p. 29.

stirred the ground, to a wide range of different types now in use.

Mr. Richard Inwards, who was born in April 1840, was elected a Fellow of the Society in 1862, and has now been a Fellow for 70 years. Mr. Inwards served as President in 1894-5.

Another Fellow of long standing, Mr. John Hunter, of Belper, Derbyshire, who was elected in 1877, recently celebrated his golden wedding.

Correspondence

To the Editor, *The Meteorological Magazine.*

Summer Thunderstorms

The annual census of summer thunderstorms in the British Isles will be commenced on April 1st next. I shall again very much appreciate the valuable help of your readers in the work of observation. The main details required are the place, date and time of the occurrence between April 1st and September 30th next, of thunder, lightning or hail, with direction in which the lightning is seen, especially at night. In the case of actual thunderstorms additional information of the following character will be welcome :—

1. Time of first observation of thunder or lightning, with direction and estimated distance.

2. Time of commencement of very heavy rain or hail, *or* approximate time of nearest approach of storm, with direction and estimated distance.

3. Approximate time of final observation of thunder or lightning, with direction.

4. Severity of storm; changes in direction or strength of wind, changes in temperature, &c., during the storm.

It is essential that the position from which the observation is made should be specified by mentioning the approximate distance and direction from a railway station or other point which may be identified on a large scale map. Please state whether the times are those shown by public clocks or Greenwich Mean Time.

In thanking all those who were good enough to send in data last summer I may mention that a report is in preparation and will be forwarded to observers in the course of a few weeks.

S. Morris Bower.

Langley Terrace, Oakes, Huddersfield. March 31st, 1932.

Observation of Aurora at Aberdeen, March 28th, 1932

The aurora when first observed at 20h. 30m., G.M.T., had the form of an arch, faint, white in colour with little or no shimmering, elevation about 10°; the arch increased in

brilliance, and rose in elevation to between 25°-35° by 21h. 10m., showing as a homogeneous arc stretching from north-west—north-north-east with a fainter glow below it. Between 20h. 45m. and 21h. 15m. there was considerable streamer activity to the north-north-west, the rays pulsating from the arc almost to the zenith. The aurora gradually faded to just a faint steady glow by 22h. 30m., after which time nothing further was noticed, this probably being due to the glare of the street lights on the slight haze. During the whole time I watched this display there was little or no change of colour except in the extreme north-west, from which quarter there appeared to be a pale greenish glow.

It might be of interest to note that the edges of some bands of lenticular alto-cumulus appeared to be lit up by the auroral light; also to the north-west an isolated lenticular-shaped cloud apparently of still higher alto-cumulus type, had not only its edges but its lower surface lit up; this phenomena being first observed just before 20h. 30m. while the aurora was moderately faint or only just visible.

J. F. OLIVER.

The Observatory, Aberdeen. March 29th, 1932.

Solar Phenomena observed at Hastings

At 16h. 45m. G.M.T. on March 25th, 1932, a parhelion was observed to the left of the sun while at the same time cloud in the vicinity and also to some distance from the sun showed iridescent colouring, the most striking colour being a brilliant green. After a short period another and brighter parhelion was observed to the right of the sun, and between 17h. 30m. and 17h. 40m. a white sun-pillar was seen extending slightly below the sun, and upwards almost to a slightly curved arc of contact situated about 22° from the sun. Although the pillar was visible to the naked eye, it was best seen with the black mirror owing to the brilliancy of the sun at the time. The phenomenon faded before 18h. but the contact arc, with diminishing intensity remained visible almost to sunset. At no time was the ordinary halo observed. These phenomena were observed in cirrus and cirro-stratus cloud moving from between south-west and west-south-west with a surface wind between ESE. and E. moderate to fresh in force. The interference colours also observed were, however, observed in a slightly lower cloud of a high type of alto-stratus.

A. E. MOON.

39, *Clive Avenue, Clive Vale, Hastings. March 28th*, 1932.

Optical Phenomena

Unusually brilliant and luminous mock suns were observed on March 25th from 2 p.m. to 5 p.m. together with a very bright

prismatic upper arc of 22° halo. Up to 4 p.m., only a small amount of lenticular cirrus was present, the sky being of a deep blue and the sun showing a sharp disc. After 4 p.m., cirrus and cirro-cumulus, both of a lenticular type, increased considerably.

At 6 p.m. on the same date, a white sun pillar was visible extending about 15° above the sun, and showed a marked glittering effect.

An unusually red sunrise, the redness extending over the whole sky, occurred on the 26th.

Popular prognostics were borne out by the succeeding unsettled and stormy conditions.

SPENCER RUSSELL.

Worcester Park, Surrey. March 30th, 1932.

Fronts

Col. Gold's letter in the March issue leads to the general question of the blunting of thermal fronts or discontinuities by mixing processes or by travel over the surface of land and water.

When persons who stand on the fringe of meteorology question me about the reality of "fronts," my reply is always to the effect that the conception has proved invaluable in forecasting and in interpreting many anomalies in weather and climate, but that fronts are no more fronts in the literal sense than a snow-line, about which geographers and climatologists talk so glibly, is an actual line instead of being in most instances a pretty wide transitional belt between all snow and no snow. A meteorological "front" is scarcely such a sharply defined discontinuity as a geological fault, and one's experience suggests that as a rule the full change of temperature and humidity that accompanies a sudden shift of wind is not felt till a width of some miles of air have passed over a place, even in the case of narrow V-shaped depressions and line squalls. Perhaps those who work in daily contact with weather charts will state their experience in this matter.

Another matter that is causing trouble outside purely meteorological circles is the use of the term "polar front." This, to my mind, is nothing more nor less than a generalized pictorial expression of the fact that cold dry air drains away from the polar refrigerators and some time, somewhere and somehow finds itself confronted with warm humid tropical air at sufficiently close quarters for a cyclonic disturbance to ensue. But it is only locally and temporarily at least in the complex conditions of the northern hemisphere that this generalized polar front can be identified with the actual fronts of daily weather.

L. C. W. BONACINA.

35, *Parliament Hill, Hampstead. March 29th*, 1932.

[Mr. Bonacina's general description seems a fair one; there

is, however, a radical distinction between a "front" and a snow-line or geological fault. The latter are static and relatively permanent—a front is in a moving medium and, relatively, transitory.—E. GOLD.]

NOTES AND QUERIES

Academia Nacional de Ciencias Antonio Alzate

The Sociedad Cientifica "Antonio Alzate" of Mexico (founded on October 4th, 1884) has been constituted as the National Academy of Sciences under the title of Academia Nacional de Ciencias Antonio Alzate. Its offices and library have been established in the new building that the Federal Government has granted to it at Justo Sierra Street No. 19.

Rapid Falls of Barometric Pressure

In response to an inquiry a search was made recently in the Meteorological Office Library to find the most rapid recorded fall of the barometer in a short period. As information of this nature is often difficult to obtain readily, it seems desirable to place the results on record.

Three examples of rapid falls of pressure were noted, all of them in tropical hurricanes. The first is quoted in Alexander Buchan's "Handy Book of Meteorology" (Edinburgh and London, 2ed. 1868). He writes (p. 266): "Thus, during the hurricane which devastated Gaudeloupe on the 6th September, 1865, it is stated in the *Bulletin International* that the barometer at Marie Galante, a neighbouring island, was 29·929 inches at 4 a.m., 29·646 at 6.30 a.m., 29·174 at 6.47 a.m., and 27·953 at 7.40 am., having thus fallen 1·693 inches (57·3mb.) in one hour and ten minutes."

The second example is from the *Quarterly Journal of the Royal Meteorological Society*, Vol. 28, 1902, p. 39. A barograph trace is reproduced, obtained on board the "Laisang," which left Hongkong for Japan on July 30th, 1901, and encountered a typhoon on August 2nd, somewhere to the northward of the Formosa Channel, in about lat. 25°N., long. 122°E. The pen of the barogram left the chart, but the lower part of the curve was plotted from readings of a mercurial barometer. From this chart it appears that at 8.30 p.m. the reading was 28·35 inches. The barometer is stated to have read 27·35 inches at 9 p.m. The fall was thus approximately one inch (34mb.) in half an hour.

The third example is from the *U.S. Monthly Weather Review*, Vol. 58, 1930, p. 363, and refers to a storm encountered by the steamship "Coamo," on September 3rd, 1930, near Santo Domingo. At one minute past one the pressure was 27·70 inches

and a note states that " Pressure fell 0·08 in 1 minute, 1 p.m. to 1·01 p.m.; 0·20 in 3 minutes, 12.45 p.m. to 12.48 p.m.; 1·23 (41·6mb.) in 40 minutes, 11.20 to noon."

It is interesting to find that if the five readings given above are plotted they fall readily on a smooth curve passing through the origin, which gives the greatest fall in one hour as 53mb. Greater falls have no doubt occurred, but at such low readings the pen of the barograph leaves the chart and the record is usually lost. Exceedingly rapid, almost instantaneous falls also occur in tornadoes, but the barometer recovers within a few minutes; moreover the area covered by the centre of these storms is so small that there is little chance of obtaining a record.

Severe Thunderstorm in Fiji

Capt. E. W. G. Twentyman reports that a severe thunderstorm occurred in Suva, Fiji, on November 20th, 1931. The early morning was fine, clear sky and calm. At about 10h. a dense cumulo-nimbus cloud formed to the north, gradually covering the sky. Occasional distant thunder and lightning occurred. At 14h. 30m. the gentle SE. wind began to lull, followed by a squall of 14 m.p.h. at 14h. 40m. from N. by W., and severe thunder and lightning. Another squall of 20 m.p.h. occurred at 14h. 53m. accompanied by a torrential downpour, the wind falling off at 15h. At 15h. 3m. the wind came in from the ESE. increasing to 25 m.p.h. at 15h 10m., thence rapidly falling off and working to SSE. Thunder, lightning and rain ceased at 15h. 15m., 1·26in. of rain being recorded in the 22 minutes. Distant thunder and lightning occurred to the north between 16h. 25m. and 20h.; drizzle 16h. 35m. to 17h. 50m. The sky cleared about 21h. During the thunderstorm at approximately 14h. 54m. a horse was struck and killed by lightning on the wharf reclamation 367 yards north-east of this office. An Indian attending the horse received a severe shock but was otherwise unhurt.

A resident of Nasoli on the Rewa River reports that a severe thunderstorm occurred there on the 20th, accompanied by torrential rain and hail. The latter phenomenon is rather unusual for Fiji and had a very peculiar effect on the natives.

The "Spring" Drought of 1932

Droughts in the south of England are by no means uncommon, but wet weather often occurs concurrently in the north-western half of the British Isles. The rainfall of the six weeks January 21st to March 3rd was unusual in that while there was some rain everywhere in the British Isles the amounts were always small. After a few days of appreciable rainfall there was generally a renewal of dry weather until March 19th, but

in the northern half of Scotland wet weather continued.

Many stations reported unusually long partial droughts (periods of 29 consecutive days or more the mean daily rainfall of which does not exceed 0·01 inch). At Camden Square (London) there was no rain at all during the 19 days from January 22nd to February 9th, and the total rainfall for the 64 days, January 17th to March 21st, amounted only to 0·51in. Absolute droughts exceeding 19 days at Camden Square have occurred on 31 occasions since 1858, while partial droughts exceeding 64 days have occurred only twice, viz., June 4th to August 11th, 1921 (69 days), and February 28th to May 16th, 1893 (78 days).

The drought of 1932 was experienced over an exceptionally large area. At Keswick, in the English Lake District, the total rainfall January 25th to March 3rd was only 0·06in.; at Glenquoich, in the western Highlands of Scotland, from February 3rd to March 3rd only 0·44in., and at Galway from January 25th to March 19th (54 days) only 0·54in. The partial drought which occurred during the spring of 1893 lasted much longer in the south of England than that of 1932, and a number of longer periods of no rain in certain localities are on record. It would be difficult, however to find a similar period of six weeks with as little rain over the British Isles as a whole.

Statistics for February, 1932, which comprised most of the drought, are readily available. Only a few isolated stations reported no measurable rain during the month. About 95 per cent. of the British Isles received less than 1in. and half the whole area received less than 0·25in. The observers at Seathwaite and at some other stations in the English Lake District, where readings are made once a month only, reported no measurable rain, and it can be assumed that any precipitation there was less than a tenth of an inch. At Rosthwaite, in Borrowdale, where daily readings are made, the total was 0·05in. So little rain has not been recorded at Seathwaite since the record was started there in 1845. At Glenquoich, the total of 0·54in. was less than that of any month since before 1868, the previous smallest total being 0·63in. for September, 1894.

The general rainfall over the British Isles during February, 1932, was 0·5in. and the month ranks as the driest since comparable statistics became available in 1870. The general rainfall for England and Wales was 0·5in., for Scotland 0·5in., and for Ireland 0·3in. There were, however, about six drier months over England and Wales since 1870, of which June, 1925, and February, 1891, with 0·1in. are the most striking.

An endeavour has been made recently to estimate the general rainfall over England and Wales since 1727, and the statistics are being published in *British Rainfall*, 1932. An examination of these statistics suggests that months as dry as or drier than

February, 1932, have occurred on about 25 occasions in the 206 years, *i.e.*, once every 8 years. It is noteworthy that these dry months occur mainly in groups: between 1921 and 1932 there were five such months; between 1891 and 1896 three, 1840 and 1844 two, 1800 and 1809 three, 1781 and 1790 four, 1740 and 1743 six. These groups are not remarkable either for unusually dry or wet years.

The first three weeks of January were unusually wet, especially in the west of the British Isles, and there was widespread rainfall towards the end of March. Although the total rainfall January to March, 1932, was below the average the deficiency was not remarkable. The general amounts expressed as a percentage of the average, are set out below: England and Wales 75, Scotland 91, Ireland 69, British Isles 77.

J. GLASSPOOLE.

Reviews

The Combination of Observations. By D. Brunt, M.A., B.Sc., Second Edition. 8vo. Size 9 × 6in.. pp. x + 239, *Illus.* Cambridge University Press, 1931. 12s. 6d. net.

It is probably true to say that the average meteorologist has no pronounced mathematical interests, and that what might be called the " science of figures " leaves him unmoved until such time as he is called on in the course of his work to interpret the results of experiment. He then wants to know what to do, without necessarily being required to know all the various assumptions that lie at the back of the theoretical methods that have been developed to this end. He is thus in somewhat the same position as the biologist who has to take a certain amount of the theory of observational error on trust. It is not one of the least of Mr. Brunt's services to science that he published, some fifteen years ago, a valuable compendium of information on the theory of errors of observation, a book that has been of very great assistance to the practical worker. The call for a new edition shows that the book is still appreciated. A wide variety of subject matter is embraced, and the book is one of a kind that must be becoming increasingly difficult to write in this age of specialisation. Beginning with the theory of error, treated along standard lines, the author proceeds to give a detailed treatment of least square theory, and no trouble is spared to cover all the possible cases that are likely to arise, or to illustrate the methods by means of numerical examples. The book then changes its character a little, and deals with certain statistical ideas, such as alternatives to the normal law of errors, correlation and regression. It is a little unfortunate for the underlying unity of treatment of the subject matter that it is still thought necessary to use a different notation for the biometrical part from that of the theory of error proper. This is largely a matter of history,

but it is confusing to the reader, and one might hope that an author should find it possible to use the same symbol for the same thing throughout a book. This question of notation is one of the troubles in the subject dealt with, and it is not made any easier by the multiplicity of symbols in the various formulæ for "probable error." Finally we have chapters on Harmonic Analysis and the Periodogram.

Judged by the author's preface to the first edition, which has not been revised, the main theme of the book is the treatment of least squares, and it is not claimed that the last four chapters are more than introductions to the subjects discussed. It is in this last section, and in this only, that revision has been carried out in the new edition; minor alterations only have been made in the first eight chapters. A fuller treatment has been given of Pearson's development of a generalised system of frequency curves. Even so, however, it remains to a large extent academic, since there is obviously not the space to illustrate how the fitting is carried through in practical cases. A very brief discussion of multiple correlation has been added to Chapter X. These additions are welcome, but their choice only serves to emphasise the absence of many other portions of statistical theory which are of more immediate practical importance to the research worker. We must not expect too much of the author, for it is manifestly impossible to tack a complete manual of statistics on to a text-book of least squares, yet it may perhaps be urged that if choice was to be made the treatment of generalised frequency distributions might have been left for a more advanced text-book, and the space utilised in describing the practical tests of significance that take up most of the time of the statistical worker. There is a profound difference between the modern text-book on statistics and its predecessors; this book still belongs to the old school.

The chapters on Harmonic Analysis and the Periodogram are excellent. The author is an acknowledged expert in the field of Harmonic Analysis, and the chapter on this subject has been almost entirely rewritten, while its application to Periodogram analysis has been revised. One of the most interesting points discussed is the application of probability theory to the problem of the greatest amplitude of a number of periods brought about by purely random fluctuations, and the development of a criterion on this basis to test the significance of an observed period. We have a proof of the Schuster result, *i.e.*, the probability that R_s^2 shall exceed $\kappa\overline{R^2}$ is $e^{-\kappa}$, where the s'th harmonic is $R_s\cos(s\theta-\phi_s)$. $\overline{R^2}$ is the mean value of R_s^2 for all harmonics in a set of n observations, and is expressible in terms of the unknown standard deviation of the population from which the sample of observations is supposed taken. Sir Gilbert Walker's criterion follows, *i.e.*, the probability that at least

one R^2 shall exceed the limit $\kappa\overline{R^2}$ is $P=1-(1-e^{-\kappa})^{n/2}$. Putting $P=\frac{1}{2}$ for an even chance this equation gives a relation between n and κ. Brunt goes on to observe very rightly that the parameter involved in $\overline{R^2}$ is not known *a priori*, and he modifies the formula to give it in terms of the calculated standard deviation (σ) of the sample. This work is so important as furnishing a criterion for the rejection of spurious periodicities that we are glad to see the matter taken up in some detail here. One can only wish that the author had gone a little further and referred to Fisher's recent and important work on the exact distribution of the ratio of the largest of the $\frac{1}{2}n$ squared amplitudes to their sample mean. For on two points the demonstration in the book before us is incomplete. First of all to put $P=\frac{1}{2}$ does not give a sufficiently rigorous criterion for the rejection of chance periods. Fisher considers the case $P=0{\cdot}05$, so that if the observed value for the ratio reaches that given in his table there is a 1 in 20 chance of the observed greatest amplitude having arisen by chance, and we may conclude that the data point to a real period. Secondly, Walker's criterion can only be applied exactly when the true value of σ is known, and it is therefore not enough to estimate σ from the sample and to use a theory based on σ being known exactly, but one should consider the exact solution based on the estimated standard deviation from the sample, and this is precisely what Fisher does. The mathematics of the demonstration is undoubtedly difficult, but the actual application of the test is so simple that it might quite well have found a place here, and Fisher's short table could have been reproduced.

We have dealt with this point in some detail because the problem must be one of the most important that are met with in Harmonic Analysis, and methods for dealing with it cannot be too widely known. Much more than this, of course, is included in Brunt's final chapter, and an exhaustive account is given of the various methods of detecting periodicities.

JOHN WISHART.

Pyrheliometric Measurements of Solar Radiation in Upsala during the years 1909-1922. By Martin Sjöström. Upsala, Soc. Scient. Acta., Series 4, Vol. 6, No. 6, 1930.

In this paper Sjöström gives a historical survey of all the work on solar radiation carried out at the Physical Laboratory, Upsala, during the years 1909 to 1929, with full references to the early work of K. Ångström, Lindholm and Granqvist, and the more recent developments by Anders Ångström and others. The transmission of the various filters used is discussed very fully in the second chapter, and tables of the transmissibility

of the blue and green filters for different wave-lengths are given in detail.

The remainder of the paper, covering some 192 pages, gives in tabular form all the pyrheliometric measurements made at Upsala from February 20th, 1909, to November 25th, 1922. For each time of observation the tables give date, time of observation (apparent solar time), the calculated time altitude of the sun, the air mass taken from Bemporad's tables, the total intensity of solar radiation in gramme calories per cm^2 per minute, the intensities of the blue radiation and of the green radiation, the temperature, atmospheric pressure, absolute and relative humidity, and direction and strength of wind. On some days the number of observations was over 30, the weather being fine, and one day in April, 1912, 110 observations were made.

The student of solar radiation will find in these tables a mass of information of very great interest. The rapid variation of the total intensity of solar radiation which was observed on some days is very remarkable, but many other points of interest arise from a study of the tables. The book is a record of a very fine achievement, of which the Physical Laboratory, Upsala, may well be proud. D. BRUNT.

The Casella Patent Fortin and Patent Observatory Barometers, Leaflet No. 574. C. F. Casella and Co. Ltd. London, 1931.

Among the many instruments of interest displayed at the Physical and Optical Societies' Exhibition held recently at the Imperial College of Science, London, was Casella's patent Fortin barometer. Those who make use of the Fortin barometer are aware that it suffers from several defects. All will appreciate the difficulties that attend the accurate setting of the fiducial point flush with the mercury surface in the cistern. Within a short time the mercury surface, owing to impurities in, and dampness of the air, usually becomes contaminated and tarnishes.* Again, the glass cistern, which is made from drawn-glass tubing, also makes a clear view of the point and its reflection at the moment of contact difficult owing to striæ in the glass and distortion of the image from the optically imperfect glass surfaces. Obscurity is further increased by dirt settling upon the inner surface of the glass. Moreover, when the mercury surface in the cistern requires cleaning, it is the work of an expert to remove the lower part of the cistern, and upon reassembling the instrument a redetermination of the zero will be necessary. Finally, in most Fortin barometers the fiducial point is not secured to the metal scale but to the top of the cistern. Hence, any variation in the

*For further information on this subject see the article entitled "The Contamination of mercury in barometer cisterns" by J. E. Belasco in the *Meteorological Magazine*, 63, 1928, p. 181.

tightness of the screws which hold together the upper and lower parts of the cistern will alter the distance of the fiducial point from the reading scale and will thus give rise to an error in the zero of the instrument.

In their patent Fortin barometer Messrs. Casella are to be congratulated in having successfully overcome these several difficulties. The cistern is of iron and the fiducial point, of rustless steel, is rigidly fixed to the metal frame and, therefore, at an unalterable distance from the divided scale. The air entering the cistern is purified by a filter so that the mercury surface will remain bright for a very long time. If, however, it should become necessary to clean the mercury in the cistern, it can be done by lowering the adjusting screw at the base of the cistern. The air can pass through the filter in and out of the cistern so freely that on setting the mercury in the cistern it settles down immediately to its proper level. By means of an optical system a beautifully clear definition of the fiducial point and its reflected image in the mercury surface is obtained under considerable magnification. Light enters the cistern through an optically plane disc fixed at the back of the cistern and after reflection from the mercury surface, is viewed through an adjustable eyepiece. Lastly, true verticality of the instrument is easily secured by rotating the frame of the barometer about its vertical axis and adjusting the three screws below the cistern until the fiducial point makes contact with the mercury surface in all positions. There is a sense of ease, pleasure, and confidence in using this instrument and we congratulate Messrs. Casella upon a fine achievement.

Messrs. Casella also exhibited their patent Observatory barometer, which is a form of Newman barometer. Observation of the fiducial point and its reflection in the mercury surface in the cistern is facilitated by an optical system similar to that in use in their Fortin barometer described above. The sliding vernier usually employed for setting to the top of the mercury column is dispensed with. Instead a very fine point is fused into the barometer tube. This tube is fixed inside a brass tube which is raised or lowered by a rack and pinion until the point comes in contact on the surface of the mercury. A fine adjustment screw brings the point into exact coincidence with its reflection, the point and its reflection being viewed through a microscope, the eyepiece of which is brought near to the scale divisions of the instrument by means of a system of prisms. On the outside of the brass tube is screwed a vernier which, as the tube moves up or down, travels alongside the scale divisions and permits readings of the barometer to be taken to 0·01 mm. When reading the barometer the point is set to the top of the mercury column and then the fiducial point (to which is attached the barometer scale) is set in the cistern. High praise is due to Messrs. Casella for their very ingenious method of overcoming the uncertainty which usually

attends the setting of the vernier to the top of the mercury column. One need no longer be troubled when the mercury meniscus is flat.

J. E. BELASCO.

Meteorological Observations for 1929. Prepared in the Meteorological Office, Wellington, New Zealand. Size 12¼ × 10in., pp. 23, Wellington, N.Z. Dept. of Scientific and Industrial Research, 1931.

Monthly summaries of the general climatological elements are given for some 49 stations, monthly sunshine totals for 26 stations, wind velocities (by Robinson anemometers) for 13 stations and pressure for 7 stations.

The rainfall for 1929 was, on the whole, slightly above normal. The year was remarkable for the comparative absence of westerly winds and for the unusual frequency of cyclonic disturbances. An unusually large number of heavy rains were recorded and many parts of the country experienced flooding. From June onwards low mean temperatures were recorded in each month, and vegetation was generally retarded by about a fortnight. The year was, nevertheless, a good one for those engaged in agricultural pursuits.

J. GLASSPOOLE.

Wetterhaftigkeit. By Gerhard Castens. Gerlands Beiträge zur Geophysik, Leipzig, 33, 1931, pp. 268-85.

This attempt at clarifying ideas on the subject of the persistence of weather types, *i.e.*, of the non-periodic variations in weather, is based chiefly on temperatures from Hamburg and Dar-es-Salaam, two towns which sufficiently represent the climatic contrast between middle and tropical latitudes. A method used by previous writers is the comparison of the hourly variations in temperature averaged for different months over several years. It is shown that this method is inadequate, even if the mean daily changes in the temperature are eliminated; in particular it fails to take into account the typical " April weather " at Hamburg. The time intervals for the temperature variations are then increased, taking as units 2, 4, 6, . . . 48 hours, and again 1, 2, 3, . . . 16 days. It is not until the interval becomes several days that results are obtained which give adequate expression to the climatic differences between Hamburg and Dar-es-Salaam, and in these results are indications of seven- and eleven-day periods. These conclusions are supported by a comparison of the ranges of temperature and pressure at the same stations. The paper concludes with some remarks on its bearing on forecasting, which appear rather more hopeful than practical.

A. F. CROSSLEY.

Books Received

Summary of the Meteorological observations made at the Meteorological Stations in the Netherlands West Indies during the year 1930, compiled by the Royal Dutch Meteor. Inst., The Hague, 1931.

Deutsches Meteorologisches Yahrbuch für Bayern, 1930.

The Bavarian Meteorological Yearbook for 1930 contains as usual a number of valuable appendices, among which may be mentioned "Singularitäten im jährlichen Witterungsverlaufe auf der Zugspitze!" by A. Schmauss. "Beiträge zum internationalen Monat, Mai 1926," by L. Egersdörfer. "Die Zugspitzbahn-Versuche," by A. Büdel. "Witterungsbeobachtungen am Bodensee," by R. Holtzhey. "Die Münchener Registrierballonfahrten im Jahre 1930," by P. Zistler and H. Zierl.

Obituary

We regret to learn of the death at the age of 80 of the well-known astronomer, M. Guillaume Bigourdan, late Director of the Bureau International de l'Heure, Paris.

The Weather of March, 1932

Pressure was above normal over western United States, western Canada, Greenland, Iceland, northern and central Europe and northern Italy, the greatest excess being 5·8mb. at Skagen (Denmark). Pressure was below normal over the eastern United States, eastern Canada and across the North Atlantic to Morocco, south and west France, south Italy and the Balkan Peninsula, the greatest deficit, over 9mb., being near Nova Scotia. Temperature was about 12°F. and 4°F. above normal in Spitsbergen and in northern Sweden respectively, and about 4°F. below normal in south-east Sweden and Switzerland. Rainfall was generally two-thirds of the normal in Sweden, below normal in Spitsbergen, and above normal in Switzerland.

The weather of March over the British Isles was variable, generally temperature was below normal in the south-east but above normal in the north and west, while rainfall was above normal except in eastern Scotland and eastern England and sunshine below normal except in southern England and southern Ireland. The drought which was so marked a feature of the weather of February persisted generally during the first few days of March.* The 1st was a sunny day with over 9 hrs. of bright sunshine at several places, 9·5 hrs. at Dumfries and Armagh, while the 2nd was sunny in the south-east. Temperature was low in the east on these days, but rose somewhat by the 4th and 5th as a deep depression which had been centred over Iceland moved in an east-south-east direction and rain fell in Scotland and Ireland on the 4th. In the rear of this depression squally north-west winds prevailed with local hail,

* See page 67.

sleet and snow in the north on the 5th, 6th and 7th. Rain fell generally in the south on the 8th as a secondary disturbance moved rapidly from northern Ireland and intensified over the southern North Sea, 0·62in. fell at Collumpton, and 0·60in. at Jersey. On the 9th the cold weather of the north spread south and snow and sleet were reported from most parts on the 9th-11th, even as far south as Falmouth and Margate on the 10th and 11th. By the 12th an anticyclone had spread across the British Isles from Iceland and a period of dry anticyclonic weather prevailed until about the 20th. Some good sunshine records were obtained during this spell, 10·8 hrs. at Jersey on the 14th and 15th and at Hastings on the 16th and 10·6 hrs. at Portsmouth on the 13th and Hastings on the 14th. Day temperatures were high, except in the south-east, reaching 60°F. at Valentia on the 15th, but night temperatures continued low, 18°F. in the screen at Marlborough on the 13th. A trough of low pressure bringing rain generally crossed the British Isles on the 20th-22nd, but it did not displace the Scandinavian anticyclone, which dominated the weather over most of England on the 24th and 25th, these days being dry and sunny with cold south-easterly winds; 11·0 hrs. of bright sunshine occurred at Margate on the 25th and 10·8 hrs. at Clacton on the 24th. By the 26th, Easter Saturday, however, secondaries moving round a new Atlantic depression caused a renewal of unsettled weather with long periods of bright sunshine, but heavy rain in the west; 2·20in. were measured at Snowdon (Carnarvon), and 1·85in. at Borrowdale, Cumberland, on the 29th. Thunderstorms ocurred locally in the south and Midlands on the 30th and 31st. By the 31st cold northerly winds were spreading across the country in the rear of this depression and slight snow was reported from north Scotland. The distribution of bright sunshine for the month was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	75	—30	Liverpool	104	— 4
Aberdeen	72	—45	Ross-on-Wye	141	+25
Dublin	95	—28	Falmouth	150	+12
Birr Castle	134	+24	Gorleston	131	— 4
Valentia	136	+13	Kew	121	+16

The special message from Brazil states that the rainfall in the northern and central regions was scarce with 3·22in. and 2·40in. below normal respectively, and irregular in the southern regions with 0·24in. below normal. The crops generally were in good condition. Seven anticyclones passed across the country. At Rio de Janeiro pressure was 0·6mb. above normal and temperature 0·9°F. abve normal.

Miscellaneous notes on weather abroad culled from various sources.

Heavy snowstorms occurred over the Black Sea and Sea of

Marmora during the 1st and 2nd. Rain fell on the 9th in the low regions of Switzerland, breaking the drought which had prevailed there for some time. In the mountains the snowfalls on the 7th-9th were the heaviest of the winter, and from 2-4ft. of snow fell about the 13th. Over 700 men and 100 horses were adrift between the 8th and 10th on large icefloes detached by strong winds from the main icefield in the eastern parts of the Gulf of Finland. A blizzard occurred there on the 9th, but on the night of the 10th new ice was formed owing to the intense cold and nearly all were rescued on the 11th. Navigation closed at Helsinki on the 14th owing to the ice, and Memel harbour became blocked with ice on the 15th though this was drifting away by the 17th. Extensive floods occurred in the Kuban Basin and other regions of the northern Caucasus—more than 20,000 collective farms being flooded. Snowstorms occurred over the Black Sea on the 25th, but later the ice was breaking up in most of the rivers and harbours of south-eastern Europe. Three ice-breakers remained icebound between Novaya Zemlya and the mainland during most of the month (*The Times*, March 3rd-April 1st).

Stormy weather occurred round Melbourne on the 10th and a squall swept the various suburban seaside resorts near Adelaide on the 27th capsizing 22 yachts and drowning 5 people. A cyclone destroyed many houses in New Caledonia (Oceania) about the 8th and damaged a number of plantations (*The Times*, March 9th-28th).

Gales, snowstorms and bitter cold caused the death of 36 people along the Atlantic seaboard of the United States on the 6th and 7th. Tornadoes wrought havoc to life and property in Alabama, Georgia, Tennessee, South Carolina and Kentucky on the 21st and 22nd; 303 people were reported killed and 2,500 injured. Cold weather followed the storms. Nine people were also killed in a second series of storms over Alabama and western Georgia later the same week. Temperature was below normal during the first half of the month, being over 20°F. below normal at most places in the Gulf States and Ohio Valley in the week ending the 15th, but about normal later in the month. Rainfall was mainly above normal during the first week, below normal the second and about normal the rest of the month. Excessive rains were reported in the maize area of the Argentine (*The Times*, March 7th-29th, and *Washington, D.C., U.S. Dept. Agric., Weekly Weather and Crop Bulletin*).

Rainfall, March, 1932—General Distribution

England and Wales	88	per cent of the average 1881-1915.
Scotland	101	
Ireland	71	
British Isles	88	

Rainfall: March, 1932: England and Wales

Co.	Station	In.	Per-cent of Av.	Co.	Station	In.	Per-cent. of Av.
Lond.	Camden Square.....	1·52	83	*Leics.*	Belvoir Castle.....	1·68	93
Sur.	Reigate, Alvington.....	1·48	63	*Rut.*	Ridlington.....	1·62	93
Kent.	Tenterden, Ashenden...	1·52	71	*Linc.*	Boston, Skirbeck.....	1·45	93
,, .	Folkestone, Boro. San..	1·32	..	,, .	Cranwell Aerodrome...	1·49	106
,, .	Margate, Cliftonville...	·96	60	,, .	Skegness, Marine Gdns	1·56	94
,, .	Sevenoaks, Speldhurst	1·77	...	,, .	Louth, Westgate.....	1·88	89
Sus.	Patching Farm.....	1·33	62	,, .	Brigg, Wrawby St.....	1·52	...
,,	Brighton, Old Steyne..	1·22	60	*Notts.*	Worksop, Hodsock.....	1·06	63
,, .	Heathfield, Barklye....	1·85	74	*Derby.*	Derby, L. M. & S. Rly.	1·47	86
Hants.	Ventnor, Roy. Nat. Hos.	1·24	60	,, .	Buxton, Devon Hos....	3·41	83
,, .	Fordingbridge, Oaklnds	1·69	73	*Ches.*	Runcorn, Weston Pt...	1·61	80
,, .	Ovington Rectory.....	1·86	72	,, .	Nantwich, Dorfold Hall	1·67	...
,, .	Sherborne St. John.....	1·88	84	*Lancs.*	Manchester, Whit. Pk.	1·81	80
Berks.	Wellington College.....	1·49	75	,, .	Stonyhurst College.....	3·07	83
,, .	Newbury, Greenham...	2·02	89	,, .	Southport, Hesketh Pk	2·01	90
Herts.	Welwyn Garden City...	1·78	...	,, .	Lancaster, Strathspey	2·88	...
Bucks.	H. Wycombe, Flackwell	1·67	...	*Yorks.*	Wath-upon-Dearne.....	1·37	79
Oxf. .	Oxford, Mag. College..	1·76	115	,, .	Bradford, Lister Pk....	2·03	83
Nor.	Pitsford, Sedgebrook...	1·52	86	,, .	Oughtershaw Hall.....	4·58	...
,, .	Oundle.....	1·26	...	,, .	Wetherby, Ribston H.	1·85	95
Beds.	Woburn, Crawley Mill	1·46	85	,, .	Hull, Pearson Park.....	1·71	94
Cam.	Cambridge, Bot. Gdns.	1·36	92	,, .	Holme-on-Spalding.....	1·82	...
Essex.	Chelmsford, County Lab	1·10	64	,, .	West Witton, Ivy Ho.	2·29	74
,, .	Lexden Hill House....	1·14	...	,, .	Felixkirk, Mt. St. John	2·15	109
Suff.	Haughley House.....	1·40	...	,, .	Pickering, Hungate....	2·10	105
,, .	Campsea Ashe	1·70	101	,, .	Scarborough.....	2·02	112
Norf.	Norwich, Eaton..... ...	...	...	,, .	Middlesbrough.....	2·17	138
,, .	Wells, Holkham Hall	1·29	79	,, .	Baldersdale, Hury Res.	2·29	...
,, .	Swaffham, The Villa...	1·47	80	*Durh.*	Ushaw College.....	2·53	115
Wilts.	Devizes, Highclere.....	2·42	115	*Nor.*	Newcastle, Town Moor	1·57	74
,, .	Bishops Cannings.....	2·23	99	,, .	Bellingham, Highgreen	2·69	91
Dor.	Evershot, Melbury Ho.	2·76	93	,, .	Lilburn Tower Gdns....	2·71	102
,, .	Creech Grange.....	2·22	79	*Cumb.*	Geltsdale.....	3·59	...
,, .	Shaftesbury, Abbey Ho.	1·76	75	,, .	Carlisle, Scaleby Hall	3·20	131
Devon.	Plymouth, The Hoe...	2·10	72	,, .	Borrowdale, Seathwaite	9·90	94
,, .	Launceston, Werringt'n	2·18	...	,, .	Borrowdale, Moraine...	6·32	...
,, .	Holne, Church Pk. Cott.	5·06	94	,, .	Keswick, High Hill.....	3·51	...
,, .	Cullompton	2·60	95	*West.*	Appleby, Castle Bank..	2·85	106
,, .	Sidmouth, Sidmount...	2·46	101	*Glam.*	Cardiff, Ely P. Stn.....	1·87	58
,, .	Filleigh, Castle Hill....	2·72	...	,, .	Treherbert, Tynywaun	5·53	...
,, .	Barnstaple. N. Dev. Ath	2·27	87	*Carm.*	Carmarthen Friary.....	2·69	71
,, .	Dartm'r, Cranmere Pool	5·90	...	*Pemb.*	Haverfordwest, School	2·28	67
Corn.	Redruth, Trewirgie.....	2·60	72	*Card.*	Aberystwyth.....	3·07	...
,, .	Penzance, Morrab Gdn.	2·81	88	,, .	Cardigan, County Sch.	2·88	...
,, .	St. Austell, Trevarna...	3·08	90	*Brec.*	Crickhowell, Talymaes	3·00	...
Soms.	Chewton Mendip.....	2·88	81	*Rad.*	Birm W. W. Tyrmynydd	3·91	73
,, .	Long Ashton.....	2·60	103	*Mont.*	Lake Vyrnwy.....	4·72	110
,, .	Street, Millfield	1·89	92	*Denb.*	Llangynhafal.....	1·91	82
Glos. .	Blockley.....	1·80	...	*Mer.*	Dolgelly, Bryntirion...	4·94	100
,, .	Cirencester, Gwynfa....	2·51	109	*Carn.*	Llandudno.....	1·50	69
Here.	Ross, Birchlea.....	1·87	92	,, .	Snowdon, L. Llydaw 9	9·25	...
,, .	Ledbury, Underdown..	1·93	102	*Ang.*	Holyhead, Salt Island	1·48	57
Salop.	Church Stretton.....	3·43	145	,, .	Lligwy.....	1·47	...
,, .	Shifnal, Hatton Grange	1·71	93	*Isle of Man*			
Worc.	Ombersley, Holt Lock	1·64	96		Douglas, Boro' Cem....	1·67	56
War.	Birminghm, Edgbaston	1·89	99	*Guernsey*			
Leics.	Thornton Reservoir....	2·16	117		St. Peter P't. Grange Rd.	2·44	99

Rainfall: March, 1932: Scotland and Ireland

Co.	Station	In.	Per-cent. of Av.	Co.	Station	In.	Per cent. of Av.
Wigt .	Pt. William, Monreith	2·78	97	*Suth* .	Melvich	3·14	...
,, .	New Luce School	3·67	104	,, .	Loch More, Achfary	7·64	119
Kirk .	Carsphairn, Shiel	4·22	70	*Caith* .	Wick	2·05	90
Dumf .	Dumfries, Crichton, R.I	2·96	...	*Ork* .	Pomona, Deerness	3·19	113
,, .	Eskdalemuir Obs.	4·19	86	*Shet* .	Lerwick	3·35	107
Rxcb .	Branxholm	2·84	98	*Cork* .	Caheragh Rectory	3·39	...
Selk .	Ettrick Manse	2·85	56	,, .	Dunmanway Rectory	3·67	75
Peeb .	West Linton	3·20	...	,, .	Ballinacurra	3·19	112
Berk .	Marchmont House	3·17	120	,, .	Glanmire, Lota Lo	3·21	103
Hadd .	North Berwick Res.	2·38	127	*Kerry* .	Valentia Obsy	3·84	85
Midl .	Edinburgh, Roy. Obs.	2·64	134	,, .	Gearahameen	5·60	...
Lan .	Auchtyfardle	2·40	...	,, .	Killarney Asylum	...	...
Ayr .	Kilmarnock, Kay Pk.	2·79	...	,, .	Darrynane Abbey	3·39	83
,, .	Girvan, Pinmore	3·46	92	*Wat* .	Waterford, Gortmore	2·19	81
Renf .	Glasgow, Queen's Pk.	2·13	82	*Tip* .	Nenagh, Cas. Lough	1·80	58
,, .	Greenock, Prospect H.	2·42	49	,, .	Roscrea, Timoney Park	1·32	...
Bute .	Rothesay, Ardencraig.	3·10	86	,, .	Cashel, Ballinamona	1·41	51
,, .	Dougarie Lodge	2·89	...	*Lim* .	Foynes, Coolnanes	2·15	73
Arg .	Ardgour House	5·54	...	,, .	Castleconnel Rec.	2·14	...
,, .	Glen Etive	...	...	*Clare* .	Inagh, Mount Callan	2.58	...
,, .	Oban	3·10	73	,, .	Broadford, Hurdlest'n.	2·06	...
,, .	Poltalloch	4·43	116	*Wexf* .	Gorey, Courtown Ho	1·88	89
,, .	Inveraray Castle	4·87	77	*Kilk* .	Kilkenny Castle	1·42	62
,, .	Islay, Eallabus	4·17	109	*Wic* .	Rathnew, Clonmannon	1·54	...
,, .	Mull, Benmore	...	...	*Carl* .	Hacketstown Rectory	1·89	67
,, .	Tiree	...	...	*Leix* .	Blandsfort House	1·44	55
Kinr .	Loch Leven Sluice	2·44	82	,, .	Mountmellick	1·69	...
Perth .	Loch Dhu	3·60	55	*Off'ly* .	Birr Castle	1·26	52
,, .	Balquhidder, Stronvar	3·06	...	*Kild'r* .	Monasterevin	1·28	...
,, .	Crieff, Strathearn Hyd.	2·85	89	*Dubl* .	Dublin, FitzWm. Sq.	1·23	63
,, .	Blair Castle Gardens	2·71	103	,, .	Balbriggan, Ardgillan.	1·25	62
Angus .	Kettins School	2·44	111	*Me'th* .	Beauparc, St. Cloud	1·26	...
,, .	Dundee, E. Necropolis	2·59	126	,, .	Kells, Headfort	1·61	59
,, .	Pearsie House	3·00	...	*W.M* .	Moate, Coolatore	1·08	...
,, .	Montrose, Sunnyside	2·78	134	,, .	Mullingar, Belvedere	1·46	54
Aber .	Braemar, Bank	2·04	68	*Long* .	Castle Forbes Gdns	1·83	62
,, .	Logie Coldstone Sch.	...	...	*Gal* .	Ballynahinch Castle	2·67	52
,, .	Aberdeen, King's Coll.	4·15	172	,, .	Galway, Grammar Sch.	1·63	...
,, .	Fyvie Castle	3·88	143	*Mayo* .	Mallaranny	3·00	...
Moray .	Gordon Castle	2·74	118	,, .	Westport House	2·55	65
,, .	Grantown-on-Spey	3·42	129	,, .	Delphi Lodge	4·81	58
Nairn .	Nairn, Delnies	2·41	129	*Sligo* .	Markree Obsy	2·28	67
Invs .	Ben Alder Lodge	2·77	...	*Cav'n* .	Belturbet, Cloverhill	2·10	76
,, .	Kingussie, The Birches	2·18	...	*Ferm* .	Enniskillen, Portora	2·40	...
,, .	Loch Quoich, Loan	3·95	...	*Arm* .	Armagh Obsy	1·82	77
,, .	Glenquoich	5·00	51	*Down* .	Eofanny Reservoir	4·59	...
,, .	Inverness, Culduthel R.	2·39	...	,, .	Seaforde	2·07	71
,, .	Arisaig, Faire-na-Squir	2·49	...	,, .	Donaghadee, C. Stn.	1·47	67
,, .	Fort William, Glasdrum	3·30	...	,, .	Banbridge, Milltown	1·89	...
,, .	Skye, Dunvegan	3·17	...	*Antr* .	Belfast, Cavehill Rd	2·14	...
,, .	Barra, Skallary	3·16	...	,, .	Glenarm Castle	2·82	...
R & C .	Alness Ardross Cas.	3·84	118	,, .	Ballymena, Harryville	2·61	83
,, .	Ullapool	3·20	77	*Lon* .	Londonderry, Creggan	2·98	93
,, .	Achnashellach	4·04	...	*Tyr* .	Omagh, Edenfel	2·42	77
,, .	Stornoway	2·95	...	*Don* .	Malin Head	1·95	...
Suth .	Lairg	3·18	103	,, .	Dunfanaghy	2·34	...
,, .	Tongue	4·11	122	,, .	Killybegs, Rockmount	3·23	63

Climatological Table for the British Empire, October, 1931

STATIONS	PRESSURE		TEMPERATURE						Relative Humidity	Mean Cloud Am'nt	PRECIPITATION			BRIGHT SUNSHINE	
	Mean of Day M.S.L.	Diff. from Normal	Absolute Max.	Absolute Min.	Mean Values Max.	Mean Values Min.	½ max. and min.	Diff. from Normal	Mean Wet Bulb		Am'nt	Diff. from Normal	Days	Hours per day	Percentage of possible
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F	°F.	%	0—10	in.	in.		
London, Kew Obsy. ..	1021·5	+ 7·5	65	25	55·9	41·7	48·8	— 1·1	43·8	92	8·1	0·65	— 2·05	7	2·9	27
Gibraltar.....	1017·9	+ 0·7	83	46	74·1	60·6	67·3	+ 1·2	60·3	84	5·6	5·99	+ 2·68	6	..	..
Malta	1018·3	+ 2·3	85	56	73·2	63·3	68·3	— 2·6	62·7	77	5·2	4·63	+ 1·76	5	7·3	64
St. Helena	1016·9	+ 1·3	64	51	59·6	53·4	56·5	— 1·8	53·9	95	9·7	1·38	..	21	..	..
Sierra Leone	1014·0	+ 2·4	89	64	86·5	69·6	78·1	— 2·0	78·2	85	4·7	10·28	— 2·34	22	..	..
Lagos, Nigeria	1012·0	+ 0·3	89	71	85·4	75·1	80·3	+ 0·8	76·9	83	8·9	5·87	— 1·89	15	..	..
Kaduna, Nigeria	1012·9	— 0·4	95	62	91·7	66.2	78·9	+ 2·6	72·2	76	5·3	1·49	— 0·69	6	..	..
Zomba, Nyasaland ..	1010·0	— 0·9	93	58	88·6	65·0	76·8	+ 2·7	..	52	2·1	0·18	— 1·34	1	..	..
Salisbury, Rhodesia ..	1011·8	+ 0·3	92	52	85·0	60·5	72·7	+ 2·0	57·9	37	2·4	1·91	+ 0·78	3	9·2	74
Cape Town.....	1018·6	+ 1·2	87	48	69·0	53·1	61·1	— 0·1	55·2	74	5·1	2·15	+ 0·50	10	..	..
Johannesburg	1013·6	+ 0·6	87	37	74·1	52·6	63·3	+ 0·5	52·6	53	4·1	1·20	— 1·36	9	8·5	67
Mauritius	1019·2	+ 1·0	83	59	80·1	65·1	72·6	— 0·1	67·1	63	7·6	0·58	— 0·80	13	8·5	68
Calcutta, Alipore Obsy.	1009·4	0·0	95	72	87·2	76·2	81·7	+ 2·4	76·6	89	5·7	6·15	+ 1·25	10*	..	..
Bombay	1008·2	— 1·6	94	71	86·7	75·0	80·9	— 1·5	75·4	86	6·0	13·07	+ 11·40	15*	..	..
Madras	1008·2	— 0·7	95	72	90·9	76·5	83·7	+ 1·4	76·4	79	6·6	6·77	— 4·38	6*	..	..
Colombo, Ceylon	1010·8	+ 0·8	87	72	85·6	76·3	80·9	+ 0·4	77·5	78	6·2	7·03	— 6·33	16	8·0	67
Singapore	1009·9	+ 0·2	91	72	86·6	75·1	80·9	+ 0·2	77·1	80	7·8	9·21	+ 1·14	17	5·0	41
Hongkong	1014·5	+ 0·9	86	63	79·2	70·1	74·7	— 2·2	66·3	61	4·4	0·73	— 4·39	10	7·6	66
Sandakan	..	..	91	74	88·5	75·4	81·9	+ 0·5	77·6	82	..	9·13	— 1·20	12	..	..
Sydney, N.S.W.	1016·1	+ 1·3	90	45	70·5	53·6	62·1	— 1·5	57·6	61	3·6	0·89	— 1·96	10	9·1	71
Melbourne	1017·1	+ 2·3	85	39	66·1	47·0	56·5	— 1·2	50·8	56	7·3	0·83	— 1·80	10	5·6	43
Adelaide	1020·0	+ 4·0	94	41	70·4	49·3	59·9	— 2·1	52·0	45	7·0	0·49	— 1·24	6	8·5	66
Perth, W. Australia ..	1019·8	+ 3·0	92	40	72·8	53·7	63·3	+ 2·5	55·3	52	3·4	1·01	— 1·21	9	10·0	78
Coolgardie	1019·4	+ 4·3	97	38	77·2	48·6	62·9	— 0·8	53·2	47	4·2	0·38	— 0·28	3	..	..
Brisbane	1018·2	+ 2·0	90	49	77·8	57·7	67·7	— 2·1	60·8	52	4·4	0·57	— 2·01	6	9·3	73
Hobart, Tasmania....	1010·0	— 0·3	81	39	61·4	45·6	53·5	— 0·6	46·7	54	6·5	3·64	+ 1·38	15	7·0	53
Wellington, N.Z.	1013·7	+ 0·6	65	39	59·6	47·1	53·3	— 1·1	50·8	73	6·2	2·80	— 1·28	9	7·3	55
Suva, Fiji	1013·5	+ 0·3	87	63	80·4	69·5	74·9	— 0·9	70·0	73	6·7	8·98	+ 0·69	19	5·1	41
Apia, Samoa	1011·0	— 0·5	88	67	85·5	72·8	79·1	+ 0·7	76·1	74	4·9	8·34	+ 1·96	10	7·3	59
Kingston, Jamaica ..	1011·3	— 0·2	91	69	87·0	73·2	80·1	— 0·4	72·6	88	4·7	6·04	— 1·42	12	4·3	36
Grenada, W.I.	1013·0	+ 2·2	88	71	85·8	73·0	79·4	— 0·7	73·6	77	7·4	16·86	+ 9·10	27	..	..
Toronto	1017·0	— 0·5	77	34	61·1	45·2	53·1	+ 4·5	46·8	85	5·1	1·99	— 0·58	13	5·6	50
Winnipeg	1013·5	— 1·4	84	29	57·2	38·8	48·0	+ 7·3	38·4	87	5·2	2·07	+ 0·70	8	4·6	43
St. John, N.B.	1013·9	— 1·9	71	34	56·8	43·3	50·1	+ 4·8	46·2	83	6·2	5·00	+ 0·46	13	3·9	35
Victoria, B.C.	1017·1	0·0	68	43	56·4	46·4	51·4	+ 1·1	48·8	87	6·5	1·77	— 0·80	10	4·9	45

* For Indian stations a rain day is a day on which 0·1 in. or more rain has fallen.